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Original communication

Racial variation on articular surface of talus (astragalus) in North Indian population

Shilpi G. Dixit MD, DNB, Assistant Professor [a,*], Jasbir Kaur MBBS, MD, Assistant Professor [b], Smita Kakar MBBS, MD, Director- Professor [c]

[a] Department of Anatomy, University College of Medical Sciences and GTB Hospital, Dilshad Garden, Delhi 110095, India
[b] Department of Anatomy, ESIC Dental college and hospital, New Delhi 110085, India
[c] Department of Anatomy, Maulana Azad Medical College, New Delhi 110002, India

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ABSTRACT

Articular morphology, especially of the lower limb, can be modified by various stresses on bone like adoption of bipedal gait and erect posture resulting in variations of the skeleton. Effects of variations in posture like squatting, which are a part of lifestyle of certain populations, were studied on 147 tali of North Indian population and examined for differences with those from other geographic regions. The modifications were classified into nine types. The lateral squatting facet was the most frequently found variation (65.9%), the medial, combined and continuous squatting facets being 8.2%, 2.04% and 4.1%, respectively. Lateral (32.7%), medial (27.2%) and continuous (4.7%), trochlear extensions, and extensions of medial (39.4%) and lateral (12.9%) articular facets were also observed in the population studied. The findings of the present study were important markers which could help in determining the race of unidentified bones.

1. Introduction

The articular morphology of human skeleton can be modified by various stresses resulting in remodeling of bone. Modifications are more frequent in the skeleton of the lower limb due to adoption of bipedal gait and erect posture. During locomotion, the foot is rarely dorsiflexed sufficiently enough to bring the anterior border of distal end of tibia in contact with dorsum of neck of talus. But squatting is a posture that involves hyperflexion at the hip and knee and hyperdorsiflexion at the ankle and subtalar joint.[1–5]

Habitual squatting, which is a posture depending on the lifestyle of individual populations, is associated with modifications of the talus in the form of squatting facets and extensions of its trochlear and malleolar surfaces. The presence of so called squatting facets on upper surface of neck of talus and on the corresponding part of anterior margin of inferior aspect of tibia was first described by Thomson in 1889.[1] Since then, a number of squatting facets have been found on the neck of the talus by a number of workers. Anterior extensions of trochlear and malleolar surfaces of the talus may also be present.

The present study was undertaken to investigate the variations and incidence of different types of squatting facets on the neck of talus in North Indian population which can then be used as a racial marker for identification of bones of unknown race. The extensions of trochlear and malleolar surfaces were also noted.

2. Materials and methods

The study was done on 147 tali (96 left and 51 right) in Departments of Anatomy of Medical Colleges of Delhi. There was no apparent sign of physical or pathological damage in any of the tali. The tali were classified into nine types in the following way.[5]

Class I – lateral squatting facet.
Class II – medial squatting facet.
Class III – combined (both medial and lateral) squatting facet.
Class IV – continuous (gutter like) squatting facet.
Class V – lateral trochlear extension.
Class VI – medial trochlear extension.
Class VII – continuous (medial, lateral, central) extension.
Class VIII – anterior extension of lateral articular (malleolar) facet.
Class IX – anterior extension of medial articular (malleolar) facet.

Squatting facet (medial or lateral) was identified as articular/smooth area present on dorsum of the neck which did not follow the line of curvature of trochlear surface and was either separated or not separated from this surface by a transverse ridge of bone not

* Corresponding author. House No. 3164, Sector 23, Gurgaon 122017, Haryana, India. Tel.: +91 9811403533.
E-mail address: shilpidr@gmail.com (S.G. Dixit).

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covered with articular cartilage. A true squatting facet faced upwards and slightly backwards as well as the AP diameter of a facet was usually concave. Even if the squatting facets were continuous with trochlear surface, they could be identified by the fact that the concavity of the facet changed abruptly to the convexity of the trochlear surface.[6] Only a true squatting facet articulated with anterior margin of inferior surface of tibia.[7]

Medial or lateral part of trochlear surface was often prolonged anteriorly on to the neck of talus, which always continued the anteroposterior curve (convexity) of the trochlear surface. Prolongations of the trochlear surface were defined as part of the surface anterior to a line drawn across the head of the talus perpendicular to the long axis of the foot, from the superoanterior margin of the lateral malleolar to the medial malleolar surface.[6] Extensions of the trochlear surface faced upwards and slightly forwards. These articulated only with the inferior (under) surface of tibia unlike squatting facet.[7]

The prolongation of articular surfaces (medial or lateral) of talus was considered if it extended beyond the level of anterior margin of trochlear surface.

Fig. 1. Talus showing lateral squatting facet (left side).

3. Observation and results

Table 1 shows the classification of tali into nine types. The incidence of lateral squatting facet was 65.9% (Fig 1). The frequency was higher on the left side (71.9%) as compared to the right (54.9%). Medial squatting facet, however, had a very low incidence of 8.2%, more frequently so on right (9.8%) in comparison with left (7.3%) (Fig 2). Combined squatting facet was observed only in 2.04% with none of the left tali possessing it, the right being 5.9% (Fig 3). Continuous (gutter like) squatting facet was observed in 4.1% of the tali, the incidence being nearly similar on left 4.2% and right side (3.9%) (Fig 4). Lateral trochlear extension was seen in 48(32.7%) of the tali, the incidence being higher on right side (37.3%) when compared with left side (30.2%) (Fig 5). Medial trochlear extension was found in 27.2% which was more frequent on left (28.1%) than right (25.5%) (Fig 6). While studying continuous trochlear extension, it was seen in 7 (4.7%) tali with higher incidence on right (7.8%) (Fig 7). Extension of lateral articular facet was observed in 12.9%, its presence being more frequent in right tali (7.8%) (Fig 8). Medial articular surface extended more than normal in 39.4% (Fig 4). The lateral squatting facet showed maximum incidence of 65.9% when compared to other facets.

4. Discussion

The present study was done on 147 tali and variations on their articular surfaces were observed. These findings were classified into nine types namely [Class I–Class IX] (Table 1). There was no evidence of side dimorphism which was in accordance with the reports by Finnegan (1978) and Panteado et al. (1986) that non-metric traits of infracranial skeleton do not show any differences in observation with relation to side.[8,9]

Lateral squatting facet showed the maximum incidence (65.9%) in the present study similar to Das (1959) in UP population and Pandey and Singh (1990) who reported higher incidences of 41.5% and 83.2% for the same.[5,10] Findings of Charles in Indian and Thomson in Australian population were also in concordance with the present study (64% and 63.5%, respectively).[1,3] In contrast Singh (1959), Jeyasingh (1979) and Ogyucu et al. found a lower incidence of 28.6%, 3.5% and 37.7% in Indian and Byzantine population,

Table 1
Showing classification of tali in nine types.

Classification	Left (96)	Right (51)	Total (147)
Class I – lateral squatting facet	69(71.9%)	28(54.9%)	97(65.9%)
Class II – medial squatting facet	7(7.3%)	5(9.8%)	12(8.2%)
Class III – combined (both medial and lateral) squatting facet	NIL	3(5.9%)	3(2.04%)
Class IV – continuous (gutter like) squatting facet	4(4.2%)	2(3.9%)	6(4.1%)
Class V – lateral trochlear extension	29(30.2%)	19(37.3%)	48(32.7%)
Class VI – medial trochlear extension	27(28.1%)	13(25.5%)	40(27.2%)
Class VII – continuous (medial, lateral, central) extension	3(3.1%)	4(7.8%)	7(4.7%)
Class VIII – lateral articular (malleolar) facet	4(4.2%)	15(29.4%)	19(12.9%)
Class IX – medial articular (malleolar) facet	31(32.3%)	27(52.9%)	58(39.4%)

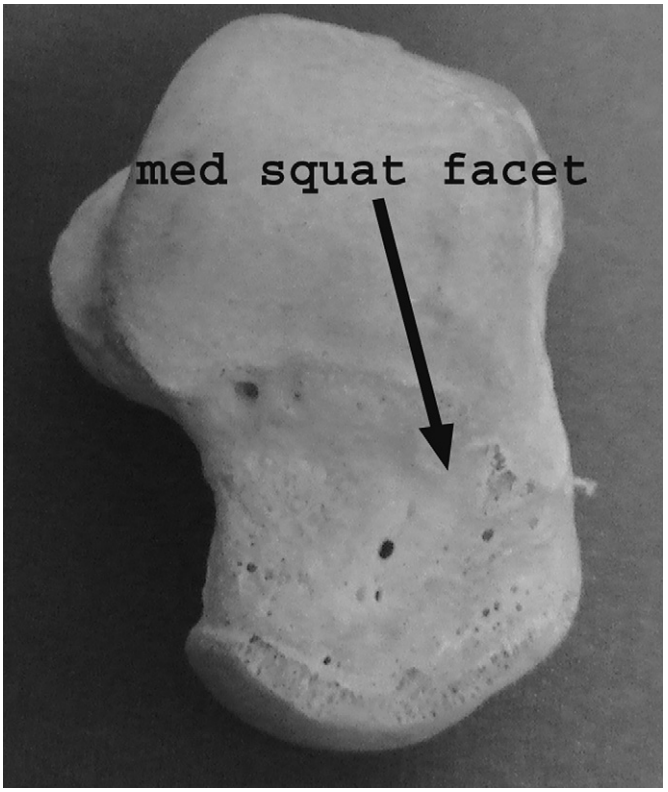

Fig. 2. Talus showing medial squatting facet (right side).

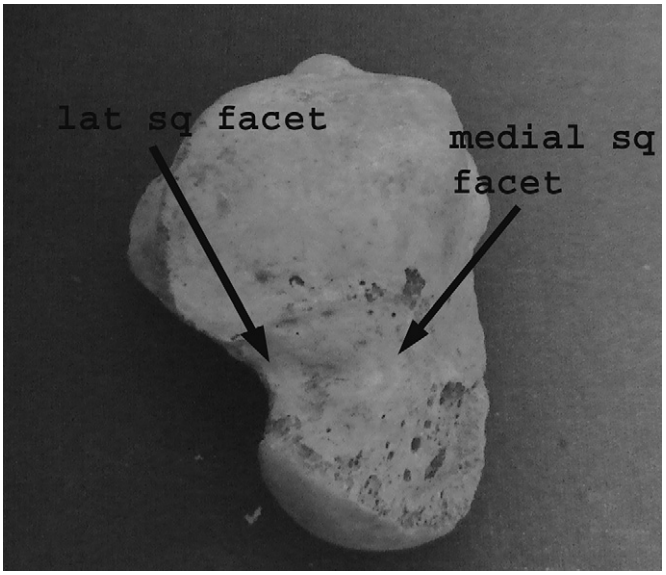

Fig. 3. Talus showing combined squatting facet (right side).

respectively.[6,7,11] Europeans and Egyptians also had a very low incidence (2.0% Barnett and 8.6% Sewell).[12,13] Though different populations exhibited different incidences for lateral squatting facet, it was the most commonly observed facet when compared to other variations (Table 2).

Medial squatting facet had a lower incidence (8.2%) in the present study, similar to that of Jeysingh (8.6%) and Das (4%) in similar population.[10,11] Pandey and Singh (1990) observed a slightly higher incidence.[5] Ogyucu et al. also found this facet in Byzantine males (0.6%) while Barnett (1954) did not observe this variation in European population.[6,12]

The incidence was low for combined squatting facet (2.04%) with similar frequencies reported by Das (3.0%) in Indian population.[10] The incidence was very low in Byzantine males (0.6%).[6]

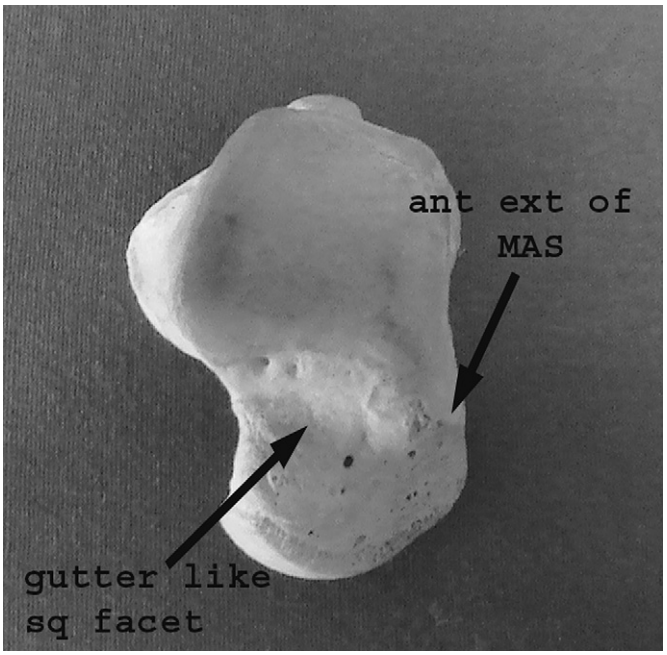

Fig. 4. Talus showing gutter like squatting facet and anterior extension of medial articular surface (right side).

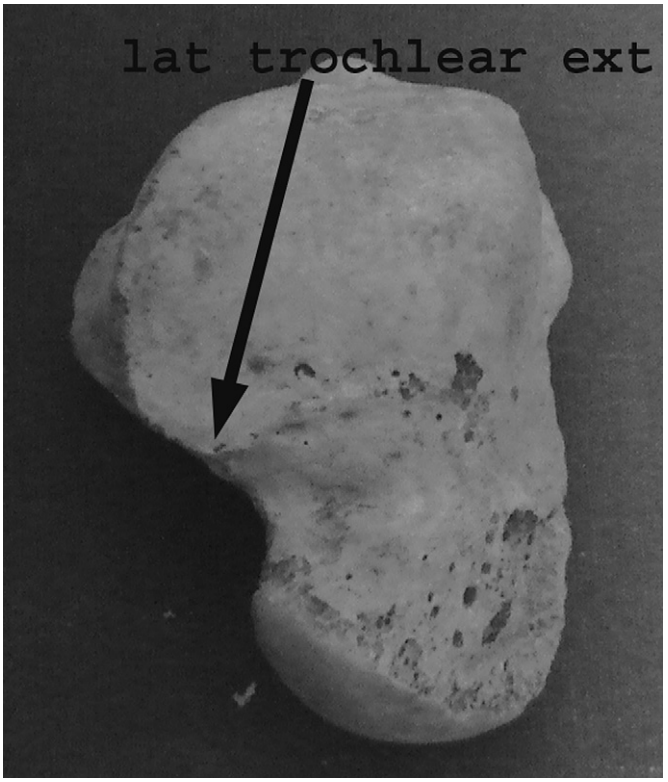

Fig. 5. Talus showing lateral extension of trochlear surface (right side).

The continuous (gutter like) squatting facet occurred with a frequency of 4.1% which was a little lower than what was reported by Pandey and Singh (10.7%) and Das (13%).[5,10] However, the incidence was very low in Byzantine males (0.6%).[6]

Lateral trochlear extension was observed in 32.7% of tali. Singh (1959) reported 24.3% and Das (1959) 24.5% for the same in Indian population in contrast to Jeysingh et al. and Pandey and Singh who

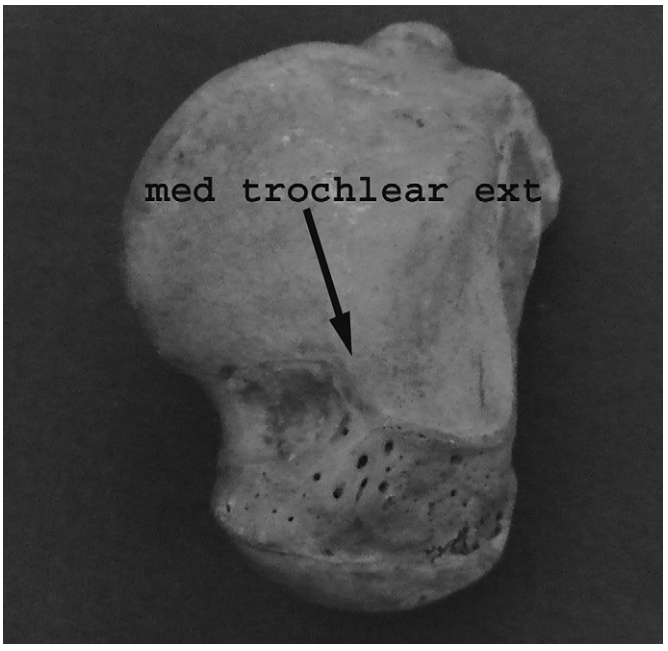

Fig. 6. Talus showing medial extension of trochlear surface (right side).

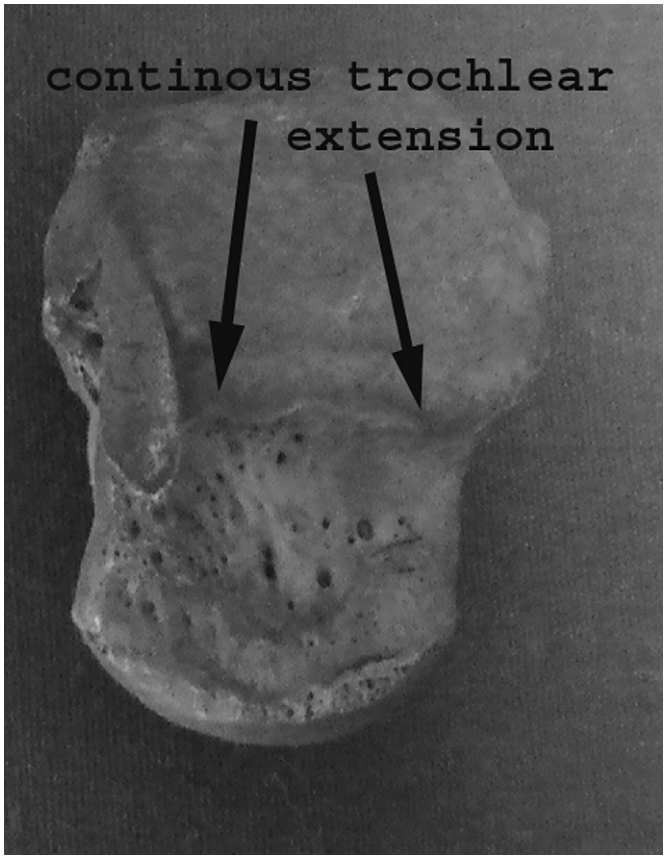

Fig. 7. Talus showing continuous trochlear extension (left side).

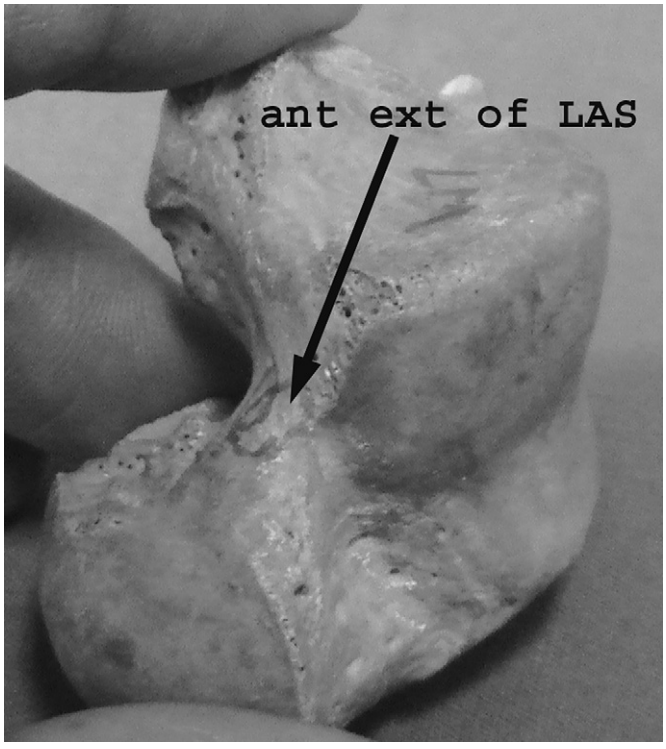

Fig. 8. Talus showing anterior extension of lateral articular surface (right side).

found the frequency to be much higher (71.6%, 90.8%). [5,7,10,11] Barnett (1954) and Oygucu et al. reported a lower incidence for the same (17%, 8.0%).[6,12]

Medial trochlear extension showed an incidence of 27.2% in the present study which was comparable to Singh (24.6%) and Das (25.5%) but dissimilar to findings of Pandey and Singh (60.3%) and of Charles (47.2%).[3,5,7,10] The presence of this feature was very low in Europeans (11%, Barnett) and Egyptians (19%, Swell).[12,13]

Continuous trochlear extension exhibited lower frequency (4.7%) in the present study which was similar to Oygucu et al.'s study in Byzantine males.[6] Higher incidences were reported by Singh (24.5%), Das(22.5%) and Pandey and Singh (60.3%) for Indian population.[5,7,10] It was not observed by Barnett in Europeans.[12]

Extensions of medial articular facets were observed in 39.4% tali in comparison with 94% in the study of Singh but he described it according to forward displacement of either anterior end or posterior end or both which was not observed in our study so could not be compared.[7]

Squatting position as already described was formed when ankle joints were in a state of extreme flexion, i.e. the dorsal surface of foot closely approximated to anterior aspect of leg. Ordinarily, the locking of the joint in this position was due to the wedge shaped superior articular surface of astragalus being driven in between tibia and fibula. According to Thomson, in cases where extreme dorsiflexion was habitually maintained for long periods, locking of the joint did not take place as described but by contact of the neck of the astragalus with anterior border of the inferior surface of tibia.[1] Many other workers also described the squatting facets on talus (upper surface) and on the corresponding part of tibia.[4,7]

Thomson described the facet as a smooth cartilage covered area on the upper surface of the neck of the talus articulating in full dorsiflexion with a facet on the anterior margin of lower extremity of tibia. He staged the facet on talus from being nonexistent to a well-marked one with lots of intermediate forms. The first evidence of facet was smoothening of the bone along the outer half or one third of upper part of the neck. In some the trochlear surface was continuous with the facet while in others, separated by a non-articular ridge of bone. In some, there was only a smooth articular ridge and yet in others, the facet was clearly defined.[1]

Charles (1894) and Wood Jones (1849) in their study found that the modifications in the bones attributed to squatting were seen not only in adult of the oriental races but also in fetus and therefore concluded that they were inherited characteristics.[14,15] However, squatting facets were also present in European fetus (Barnett) proving that the Indian fetus inherited no greater expression of squatting facets than the European fetus, the fetal presence resulting likely from considerable dorsiflexion of foot occurring during intrauterine life.[12] The persistence of these features in adult life depended upon the type of life adopted by them. Many of the Europeans possessed these facets at birth, but the lack of subsequent pressure (such as would occur during squatting) allowed the attachment of the capsule to encroach upon and obliterate them (Table 2).

Present observations of squatting facets were similar to some Indian studies and also those done on Australians and Byzantine males.[2,6] These were consistent with prolonged extreme dorsiflexion of talus during squatting, an activity compatible with lifestyles of these populations (farming). The difference in occurrence of the squatting facets between apparently similar Indian populations probably reflected the sex ratios of the bones investigated as Pandey and Singh reported that the prevalence of these was greater in females than males but the increased incidence varied by only 9–16% approximately depending on the type of the facet.[5] The squatting facets were more common in Byzantine males on the lateral aspect of neck of the talus.[6] On investigation, pes valgus

Table 2
Showing comparison of findings of present study to that of other authors.

Population	Barnett (1954) (European)	I.B Singh (1959) (Indian)	Pandey and Singh (1990) (Indian)	Das (1959) (Indian)	Oygucu (1998) (Byzantine)	Charles (1984) (Indian)	Thomson (1889) (Australian)	Sewell (1904) (Egyptian)	Current (2009) (Indian)
No of tali studied	100	300	262	200	175	53	11	1006	147
Squatting facet									
Lateral	2.00%	28.60%	83.20%	41.50%	38%	64.00%	63.60%	8.60%	65.90%
Medial	0		17.60%	4%	0.60%	0			8.20%
Lateral and medial			11.80%	3%	0.60%				2.04%
Continuous (gutter like)			10.70%	13%	0.60%				4.10%
Trochlear extension									
Lateral	17%	24.30%	90.80%	24.50%	8.00%				32.70%
Medial	11%	24.60%	60.30%	25.50%	10.90%	47.20%		19%	27.20%
Continuous		30.30%	58.00%	22.50%	4.60%				4.70%
Articular extension									
Lateral									12.90%
Medial									39.40%

deformity was present in them which was perhaps due to prolonged standing and walking on a hard surface (consistent with their lifestyle). It resulted in outward deviation of the foot at the talocalcaneal joint bringing the lateral surface of the talus into contact with the anterolateral margin of inferior end of tibia suggesting that extreme dorsiflexion was perhaps not the only reason for the modification of upper surface of neck of talus.[16] The incidence of these facets was higher as compared to those reported in Europeans (Table 2).

Trochlear extensions (medial or lateral) on the other hand could be differentiated from true squatting facet by the fact that the surface continued the line of curvature of the trochlea and therefore came in contact with undersurface of lower end of tibia and not its anterior margin during dorsiflexion and there was generally no separate facet on tibia for this extension. The squatting facets faced upwards and occasionally slightly backwards, while the extension faced upwards and forwards. The anteroposterior diameter of the facets was concave in contrast to that of the extension which was convex upwards. Findings of Pandey and Singh of lateral squatting facets were higher than our study in similar population and were perhaps due to the fact that in some instances, facets described by them, were in reality merely lateral extensions.[5] The disjunction in the incidence of squatting facets and trochlear extensions between different populations suggests that their presence was not determined by exactly the same factors. According to Singh, in the examination of dissected specimens, both medial and lateral trochlear extensions were accompanied by corresponding changes in the shape of articular surface of tibia. However, articulation with tibia occurred only at the extreme limit of dorsiflexion.[7]

Forward prolongation of the medial articular surface of talus was much more pronounced in Indian bones than in those of Europeans. It was usually accompanied by a corresponding anterior displacement of posterior end which was similar to findings of Singh who observed this in both adult and fetal specimens.[7] Barnett observed this association in European fetal tali but not in adults.[12] He suggested that during growth, there was a backward shift of the medial articular surface of the talus relative to the upper surface.[12] Others also had similar findings but in adult tali like in Punjabis (Charles 1894), in ancient Egyptians (swell), and in Australians (Inkster).[13,14,17] Both Singh and Barnett stated that medial articular surface of the talus was frequently curved medially on its anterior end.[7,12] However, in our study we did not observe this feature hence it could not be compared. The first one to describe these prolongations was Charles (1893) who attributed them not only to squatting but also to the 'Sartorial position' which was described as plantar flexion and strong adduction at the ankle.[3] According to him, the variations in medial articular surface helped adopting the sartorial position. The studies done by Barnett and Singh, however, stated that the anterior part of medial articular surface and the corresponding part of malleolar facet were in complete apposition only when the joint was completely dorsiflexed suggesting that this variation was also due to extreme dorsiflexion like in squatting and not due to sartorial position.[7,12] Wood Jones (1949) also stated that this forward prolongation of medial articular surface may be present even in people who possess marked mobility of the ankle joint, who never adopted sartorial posture.[15] Singh in his study found medial extension of trochlear surface was always accompanied by forward prolongation of medial articular surface (55%) which was dissimilar to our study (17%).[7]

To the best of our knowledge, there was no study describing forward prolongation of lateral articular surface. It may be perhaps due to the backward shift of the lateral articular surface of the talus relative to the upper surface during growth similar to that of medial articular surface. There also may be complete contact extending slightly anteriorly between the lateral articular surface of fibula and talus in extreme dorsiflexion during squatting position.

Thomson gave a phylogenetic view to his study by including astragali of gorillas, orangs, baboons and chimpanzees also. He found the squatting facet on neck of talus well marked on Orangs and Baboons, in few gorilla specimens but not in chimpanzees. He explained that although the cause of the presence of facet was the same that is extreme dorsiflexion of ankle joint but it was because of different use of the foot as anthropoids did not squat like man. They did not rest the weight of the body on the sole of foot, but when they used their foot for climbing, weight of body was sustained by foot with ankle joint extremely dorsiflexed. Therefore probably the facets were well developed in Orangs (expert climbers).[1]

According to Boulle, tibial retroversion and lateral squatting facet were two skeletal markers closely related to habit of squatting in which the former was 'precocity indicator' and latter showed intensity or regularity of use of squatting posture. He indicated that squatting was a regular behavior used till the end of Middle Ages after which a progressive decrease in its use.[18]

Clinically, the study of squatting posture in recent times was important as prolonged squatting was found to be a strong risk factor for tibiofemoral knee osteoarthritis in elderly Chinese subjects in Beijing where this posture was commonly adopted.[19]

There was also the need for elaboration of impact, that stress induced bone remodeling would have on physical and sports performance in modern times and possible measures that could be taken for prevention and correction.

To summarize, the four main features of biological identity are sex, age, stature and ethnic background. A reliable estimation of race from the skeleton by using various criteria is important while dealing with undocumented skeletal material, whether it is in the field of medicine or work with prehistoric osteological collections. Therefore these facets can be useful in forensic science for identification of race of unidentified bones.

5. Conclusion

Individual populations exhibited different incidences of modifications of skeleton especially lower limb that reflected their life style. Some human skeletal features that were produced through actions of their bearers during life allow reconstruction of postures. Therefore we believe, the persistence and development of squatting facets in the adult resulted from remodeling due to stress placed on the bone in life, and their presence postmortem provided information about previous lifestyle, like tibial retroversion and lateral squatting facets were two skeletal markers closely related to squatting. The presence of these variations due to squatting posture decreased from Middle ages onwards reflecting changes in lifestyle.

Thus, the variations and incidence of different types of squatting facets on the neck of talus in North Indian population observed in the present study could be used as a marker for identification of race of bones of unknown race.

Conflict of interest

The authors hereby declare that they do not have any conflict of interest whatsoever.

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Ethical approval

None declared.

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